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LA-UR-#####



Los Alamos in Space

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Intelligence and Space Research Division

Aug. 26, 2014

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Precipitating Events

- **1952-1964** Advances in Nuclear Weapons
 - 1st US (1952) and Soviet (1953) thermonuclear devices
 - Britain, France, and China join the club
- **1958** Unilateral US & Russia moratoriums
- **1959** US DARPA & AEC starts Project Vela (“watchman”) using Los Alamos, Sandia expertise
- **1961** Russia breaks self-declared moratorium: **45 tests (atmospheric and underground) in 100 days**
 - US responds in kind
- **1963** Limited Test Ban Treaty: US, USSR & UK
 - Prohibits nuclear detonations in the atmosphere, outer space, or under water
 - 1st Vela launch: **space-based treaty verification**
- Other treaties:
 - 1974: Threshold Test Ban Treaty (ratified)
 - 1976: Peaceful Nuclear Explosions Treaty (ratified)
 - 1996: Comprehensive Test Ban Treaty (not US-ratified)

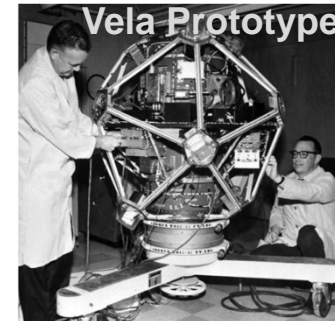
1961 Tsar Bomba, 50 Mt



Starfish Prime:
400 km 1.4 Mt



Vela Prototype



**LANL in space : intimately tied to Nuclear
Detonation Detection mission**

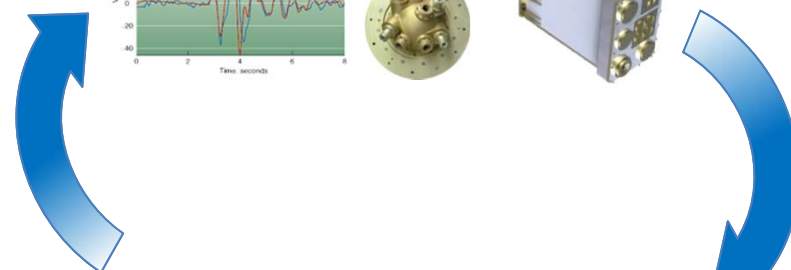
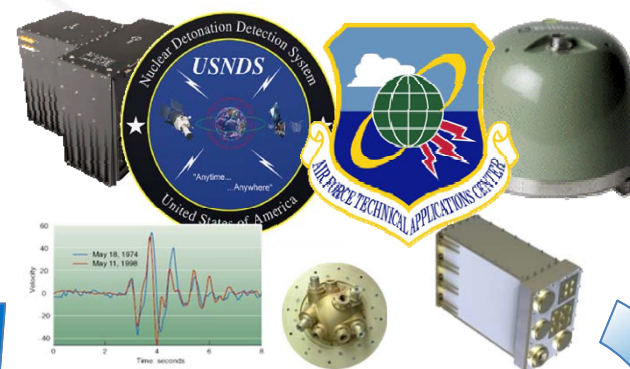
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Slide 2

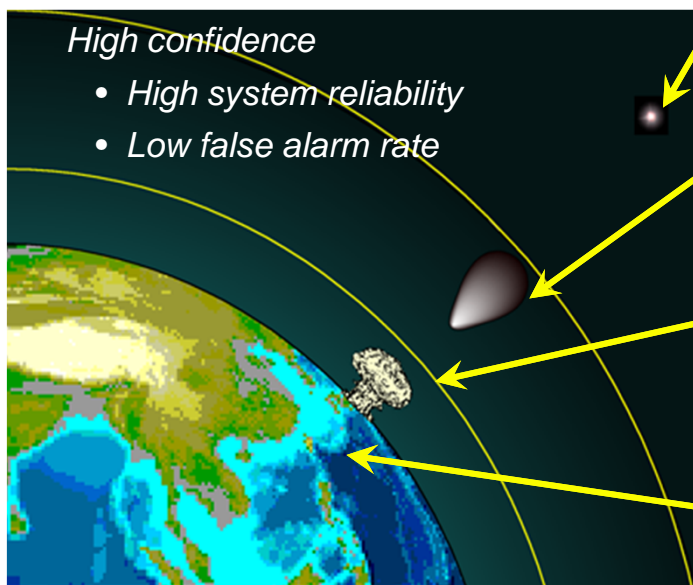
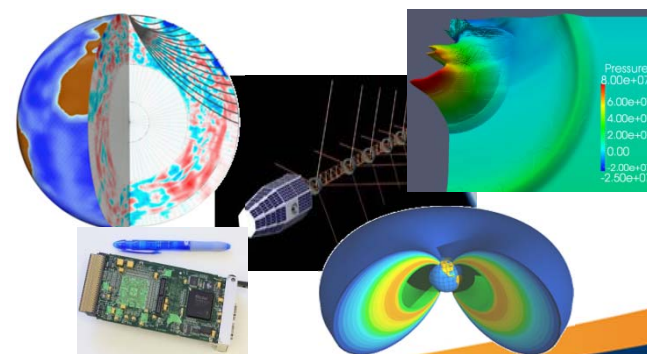
LANL's Nuclear Detonation Detection Mission

*Multiple phenomenologies are used to
detect, locate, identify and characterize
nuclear detonations anywhere, any time*

Operational Sensing Systems



Research & Development



Space NuDet

- Gamma Rays
- Neutrons
- X-rays

High-altitude NuDet

- Gamma Rays
- Neutrons
- Optical

Low-altitude NuDet

- Optical
- Electromagnetic Pulse
- Infrasound
- Radionuclides

Below-ground NuDet

- Seismic
- Hydroacoustic

Understanding the natural environment is also a core program element:

- Backgrounds in radiation instrumentation
- Space situational awareness

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LANL ST&E Research: *Maintaining and Developing World-Class Capabilities that Support the National Security Mission*

National Security Missions

Scientific Discovery Missions

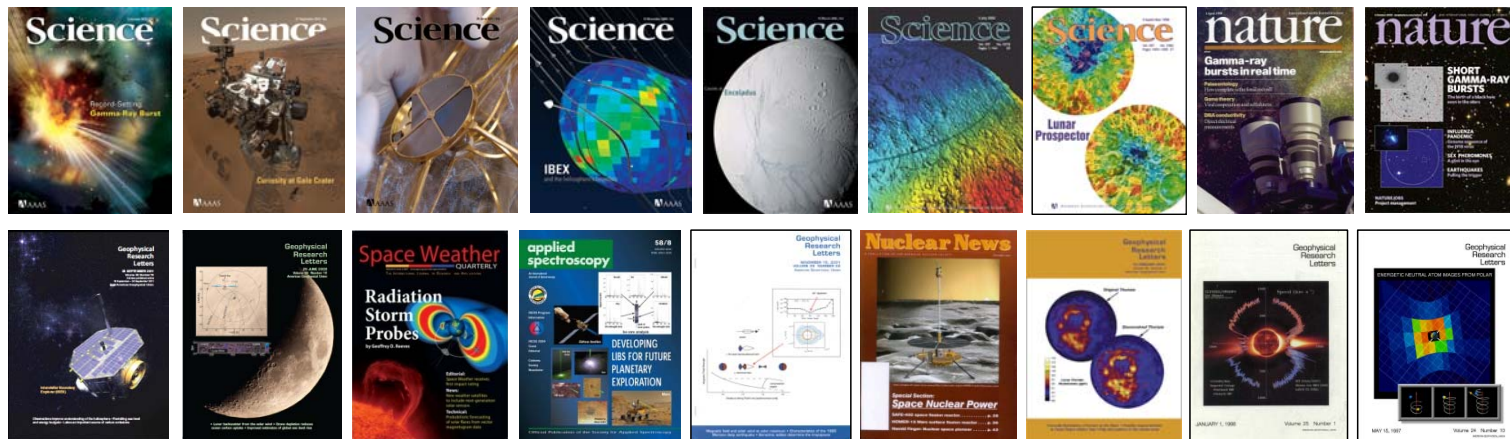
Best of Class Capabilities

Transformational STE Spiral

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Science of Signatures in Space: *A Rich Fabric of Innovation and Discovery*

- Signature Discovery



- Revolutionary Measurement: *a quest for the unknown, allow for the unexpected*
- Forward Deployment: *harsh environment, limited resources, autonomous operation*

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LANL's Thinking Telescopes

Discovering New Objects in Space

Telescope Conops: Wide FOV monitoring, rapidly-slewing foveal follow-up

Autonomous and coordinated: ≥ 6 operational telescope systems

Parallax and coverage: NM sites and HI

Extreme slewing: $50^\circ/\text{sec}$ and $50^\circ/\text{sec}^2$

Embedded health monitoring, fault detection: vibration monitors

Real-time object ID & classification: 150,000 objects every 20 sec, catalog comparison, queue and prioritize anomalies for real-time follow-up

- *Photometric: brightness vs time*
- *Astrometric: location/spatial track vs time*

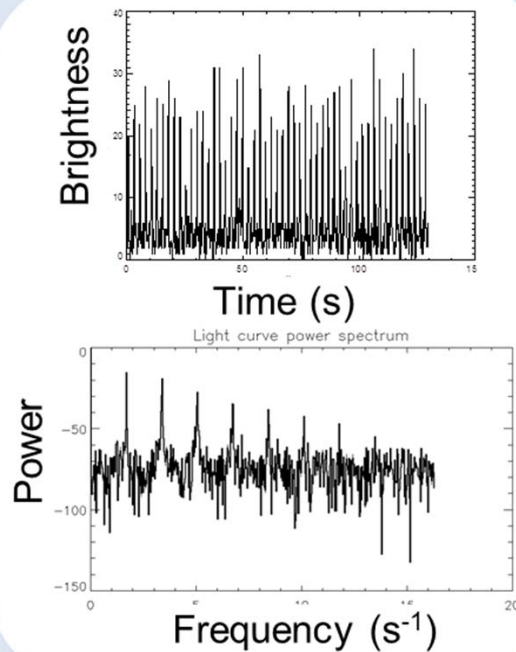


	Full Sky Monitor	Fast Follow-up
Telescope Systems	Raptors Q (R2D2), A, B	Raptors A,B,Q/P,T
Pixel Resolution	14-110 asec (0.004° - 0.3°)	1.5 asec (0.0004°)
Sensitivity (R)	$\sim 10^{\text{th}}$ to $\sim 16^{\text{th}}$ mag	$\sim 17^{\text{th}}$ to $\sim 19^{\text{th}}$ mag
Sky scan & photometric reduction	1.5x10 ⁵ objects every 20 sec	
Slew rate, accel/decel	50 deg/sec, 50 deg/sec ²	

LANL's Thinking Telescopes

Discovering New Objects in Space

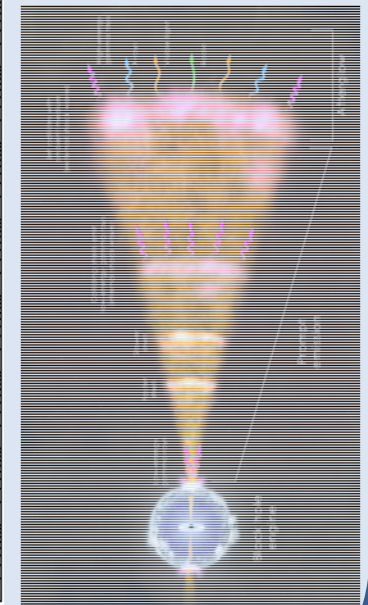
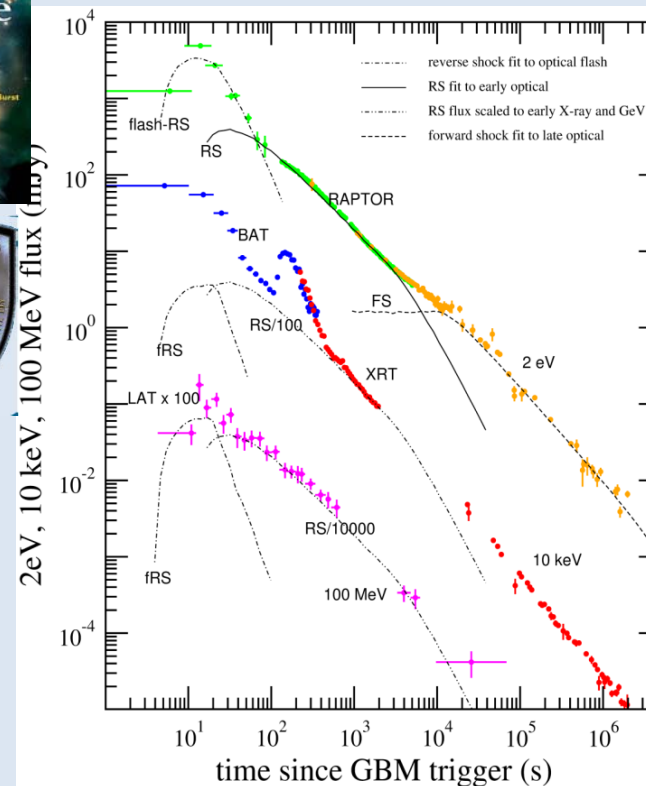
Fingerprinting Spacecraft



- Light curve of decommissioned MCI comsat (SBS-1)
- Spin period = 0.59335 s

Gamma-Ray Burst 130427A

- Brightest in more than two decades; 3.6 billion light years away
- LANL discovery: exceptionally bright optical flash, establishes the origin of the gamma-ray “afterglow” as a reverse shock



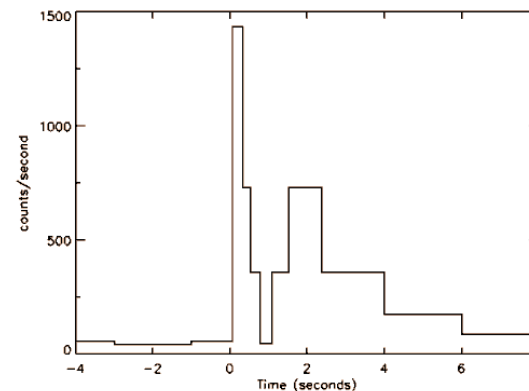
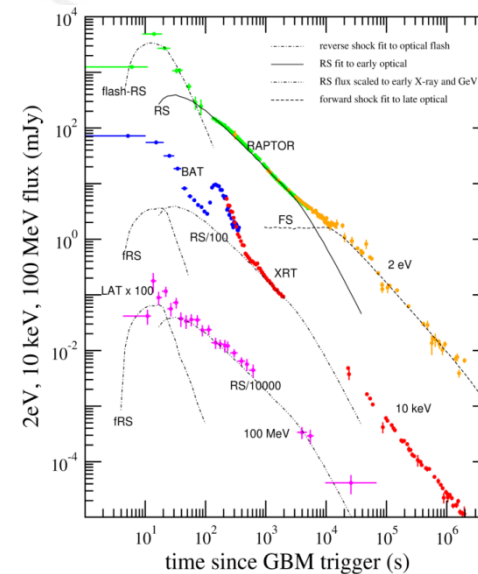
Back to the Future: *Supernovae and Our Evolving Universe*

Exploding stars, a window into the early universe and stellar evolution:

- **Discovery by Thinking Telescopes of fundamental supernova shock processes (Vestrand et al., 2014)**

Touched by a supernova:

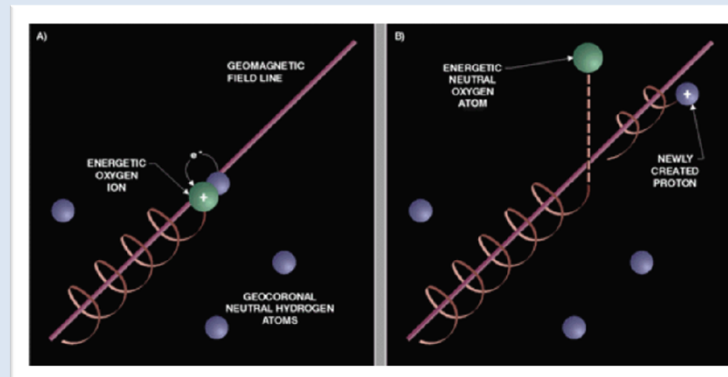
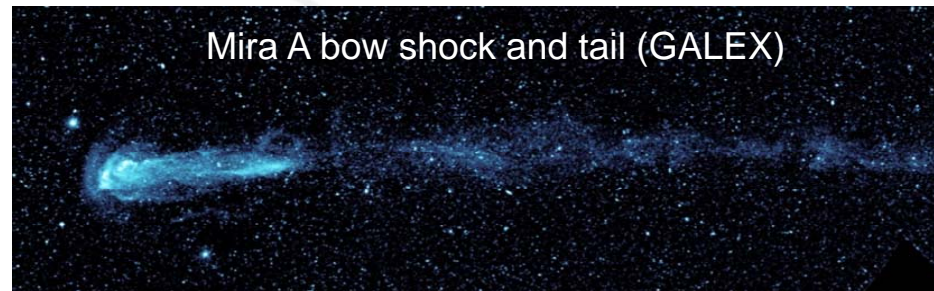
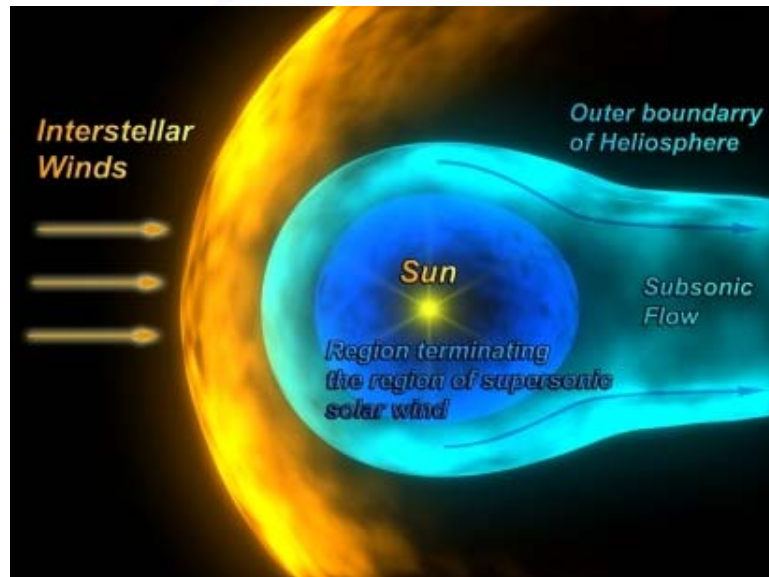
- **Discovery by Vela of gamma ray bursts (Klebesadel et al., 1973)**



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Interstellar Boundary Explorer (IBEX)

Understanding the Sun's Interaction with the Interstellar Medium



Neutral Atom Imaging:

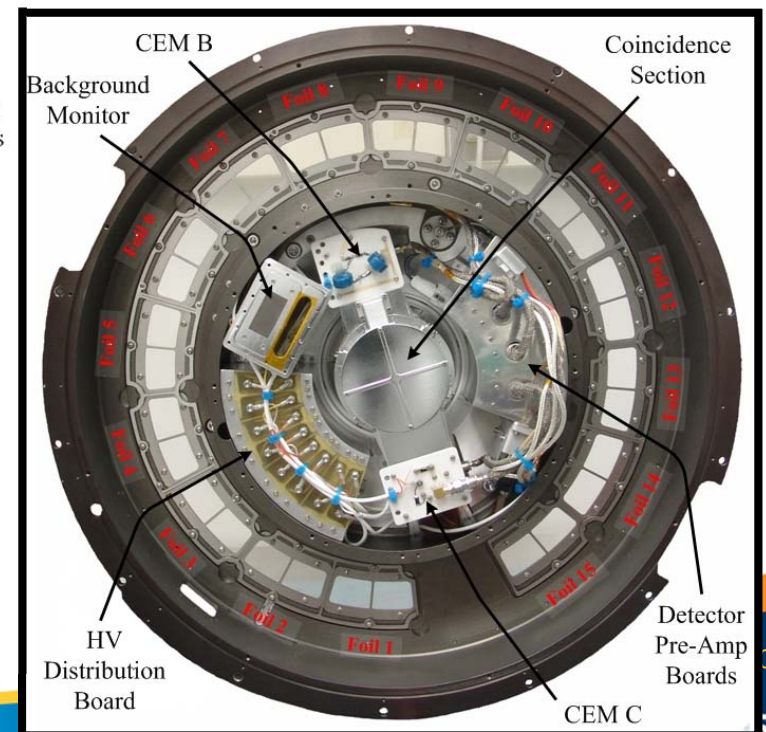
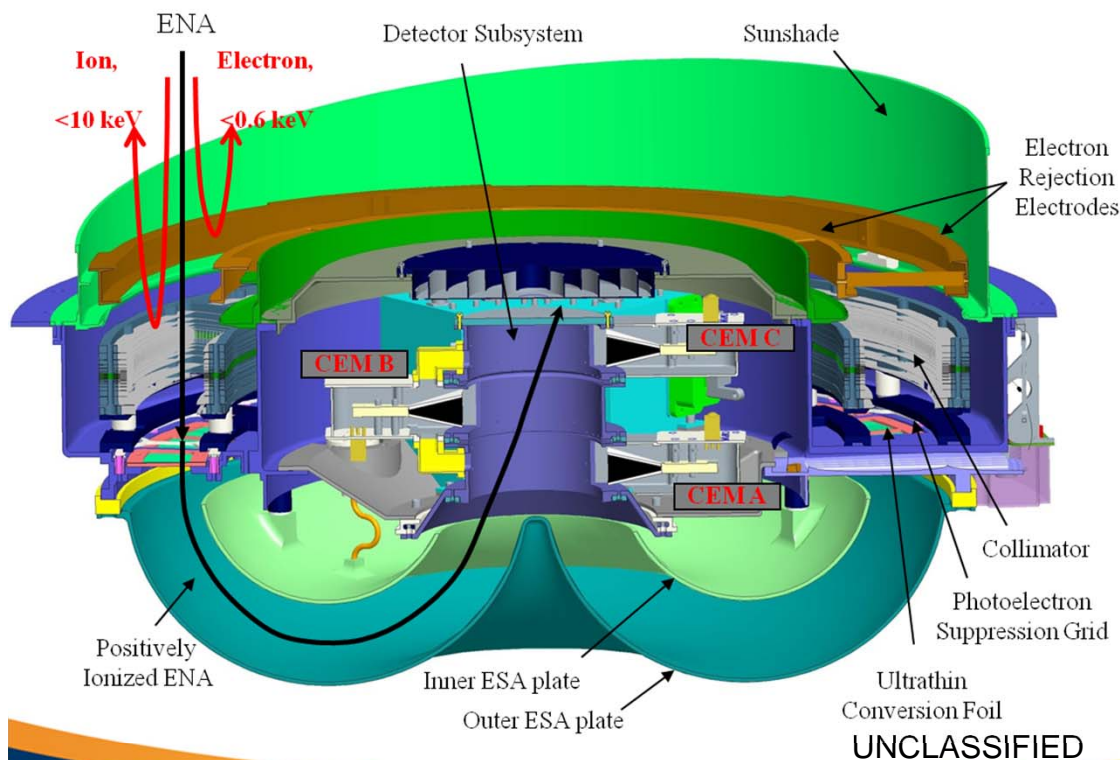
- Plasma ion grabs an electron from ambient cold neutral atom and becomes an energetic neutral atom (ENA)
- ENAs follow ballistic trajectories: long distances in straight lines

LANL-led IBEX-Hi Imager *Understanding the Sun's Interaction with the Interstellar Medium*

Measurement challenge: ENAs difficult to detect; high background environment

Measurement Strategy:

- First convert ENAs to ions using 150 cm² aperture of carbon foils, 50 atomic layers thick

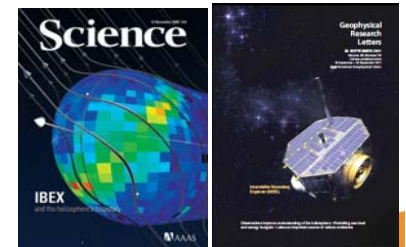
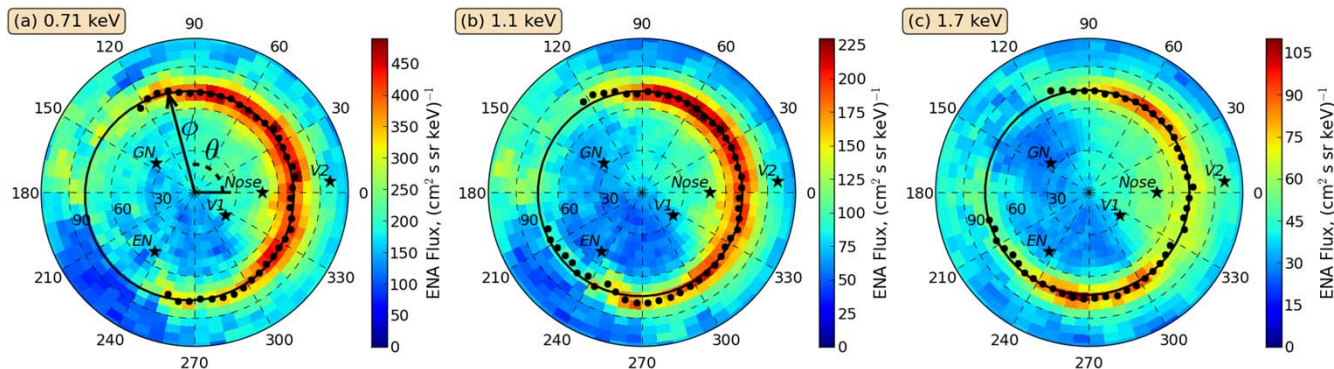
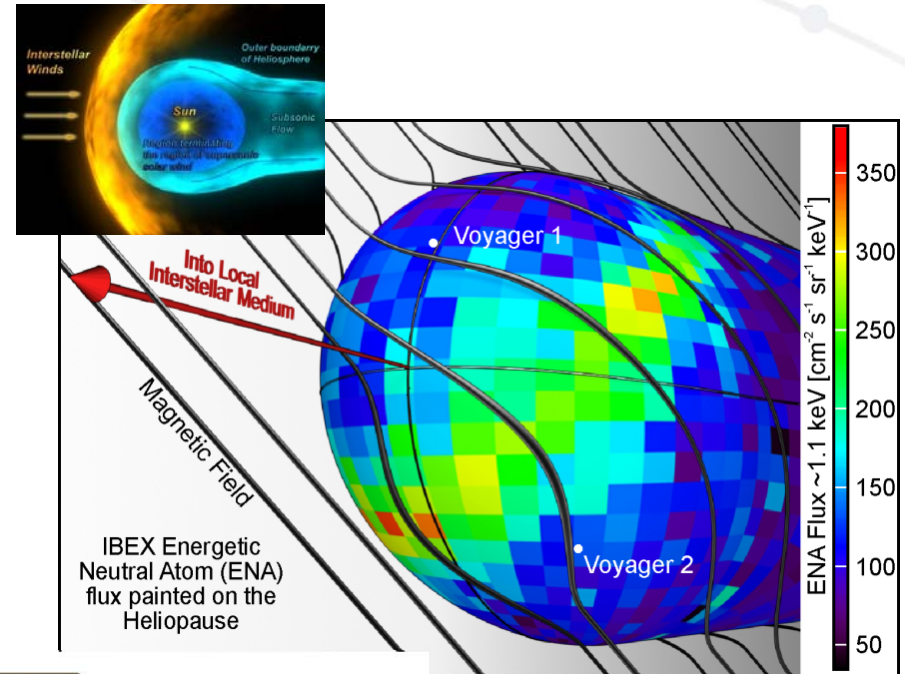


Interstellar Boundary Explorer (IBEX)

Understanding the Sun's Interaction with the Interstellar Medium

Discovery:

- An extremely circular “ribbon” of ENA emission
- At least 14 theories published to explain it; no consensus
- Center of ribbon is believed to be the direction of the interstellar magnetic field

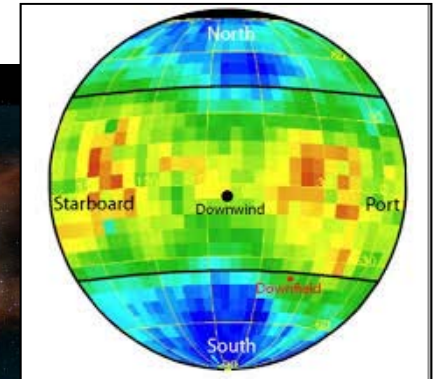
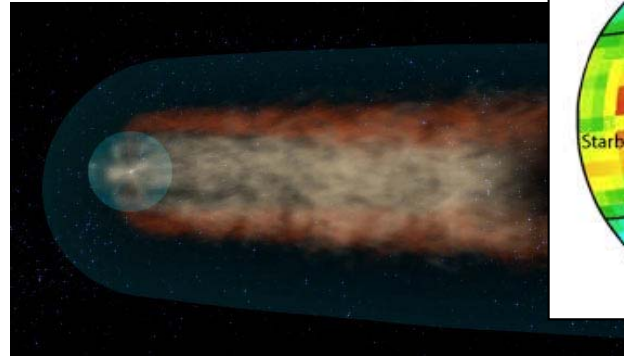


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Back to the Future: *Wakes of the Earth and Sun*

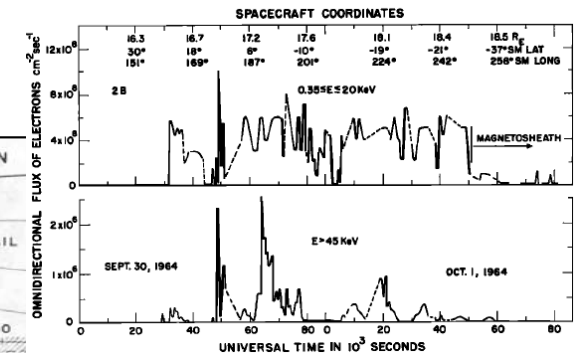
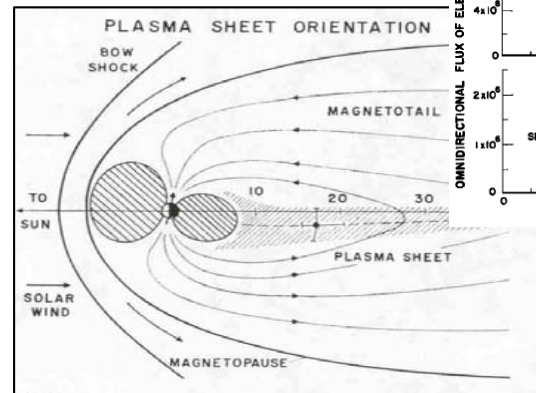
The Sun is an obstacle in the interstellar medium:

- **Discovery by IBEX of the heliotail** (*McComas et al., 2013*)



The Earth is an obstacle in the solar wind:

- **Discovery by Vela of the Earth's plasma sheet** (*Bame et al., 1966, 1967*)

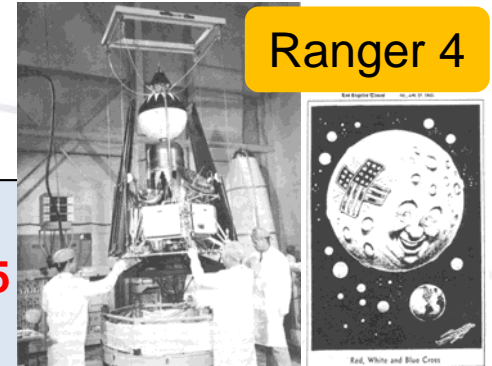


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Back to the Future: *The Moon*

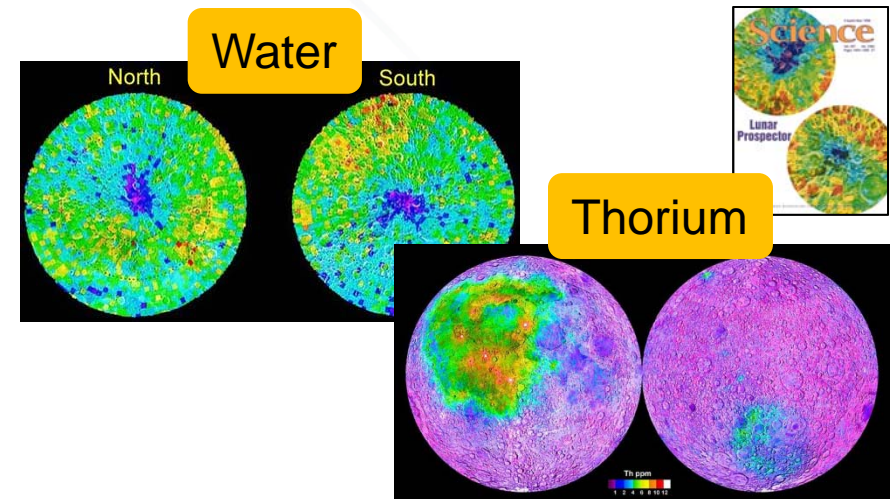
Is it cheese?

- 1st attempts of in situ lunar composition on NASA's Rangers 3-5 (*Van Dilla et al., 1962*); Atlas-Agena launch vehicles



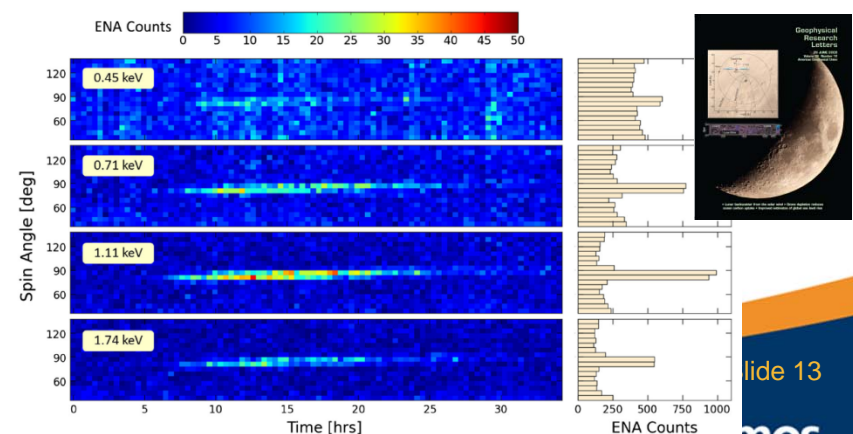
It's quite complex:

- Discovery by Lunar Prospector of water at the poles (*Feldman et al., 1998*)
- Discovery by Lunar Prospector of the global elemental distribution (*Lawrence et al., 1998*)



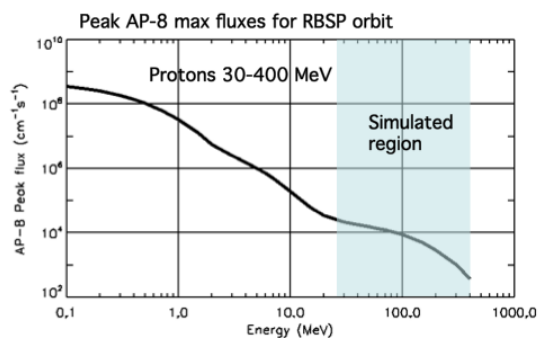
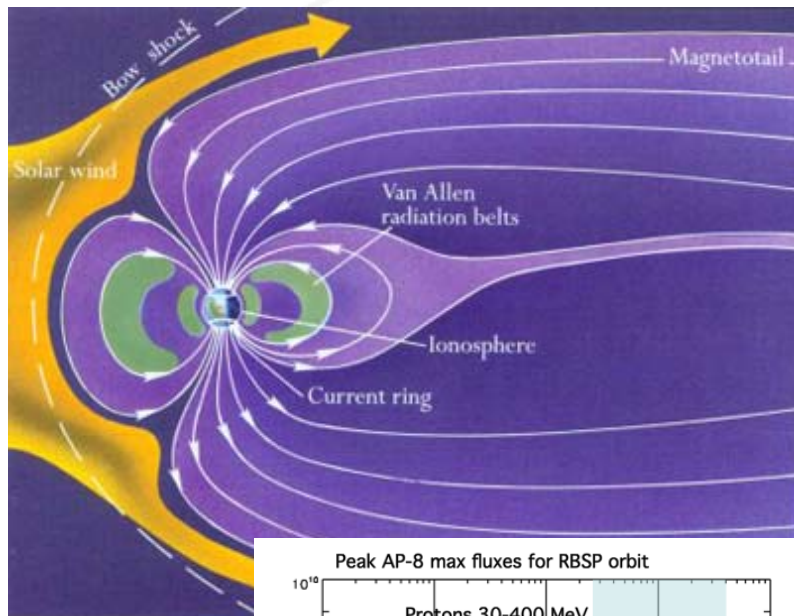
Dynamic processes at the surface:

- Discovery by IBEX of the reflection of the solar wind from the Moon (*McComas et al., 2009, Funsten et al., 2013*)

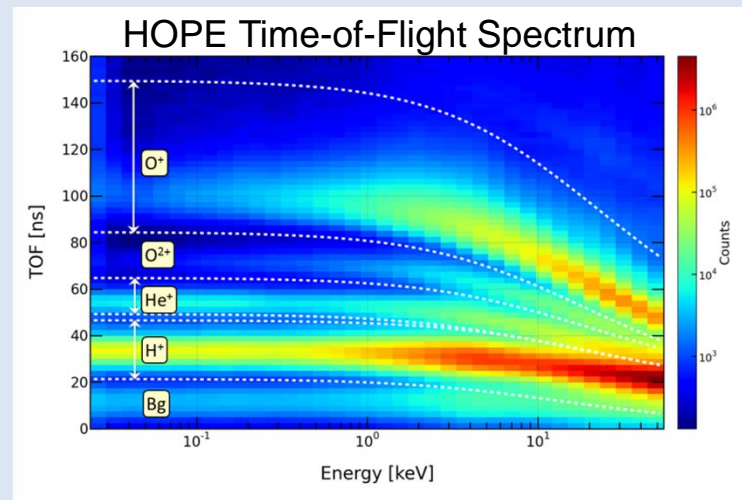
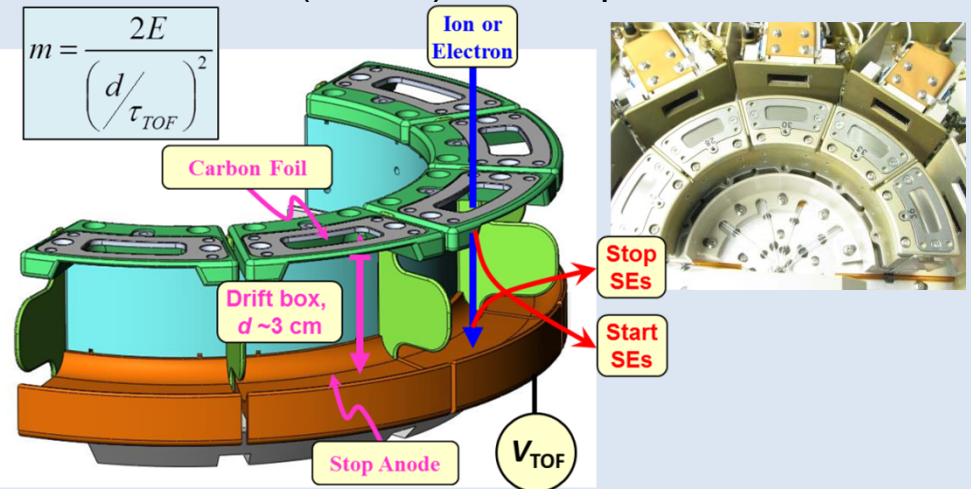


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NASA's Van Allen Probes *Understanding the structure and dynamics of the Earth's radiation belts*



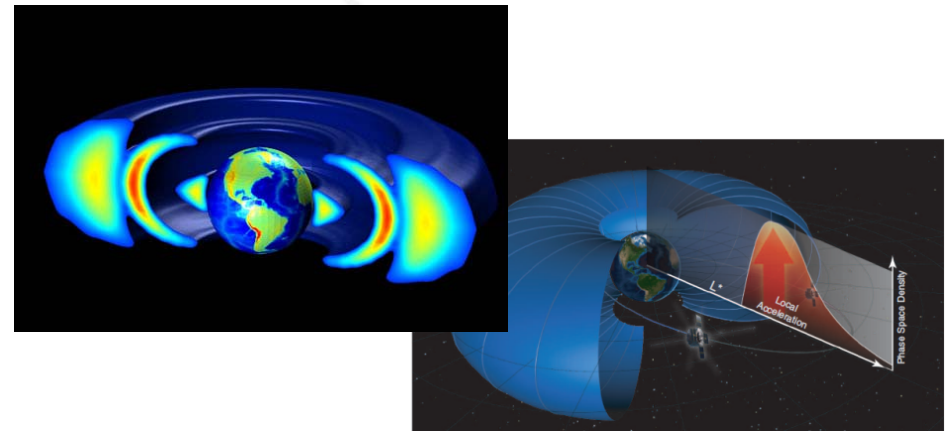
LANL-led Helium, Oxygen, Proton, and Electron (HOPE) Mass Spectrometer



Back to the Future: *The Harsh Space Environment of Earth*

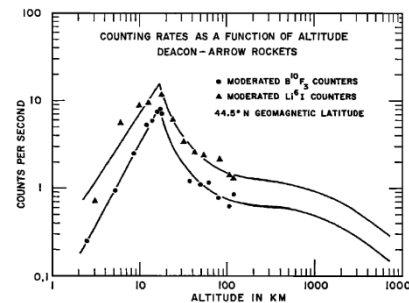
Drivers of the Van Allen Radiation Belts:

- Discovery of a third radiation belt by Van Allen Probes (*Baker et al., 2013*)
- Discovery of the electron acceleration process by Van Allen Probes (*Reeves et al., 2013*)



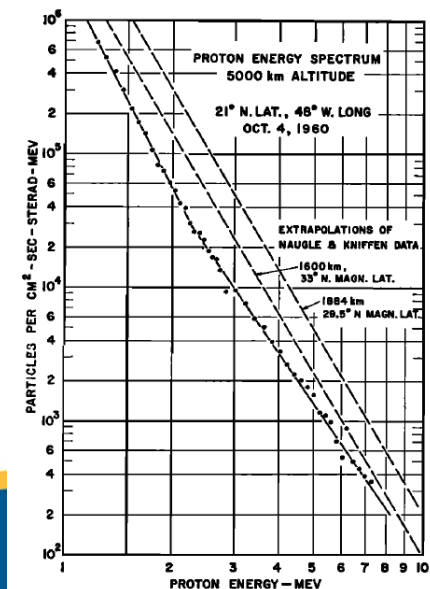
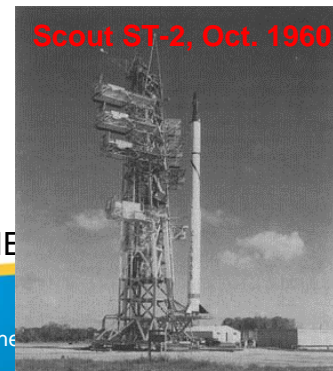
Space is harsh:

- Discovery of neutrons on Deacon Arrow VP-8 & VP-12; Atlas Pod 7-III (*Bame et al., 1960, 1963*)



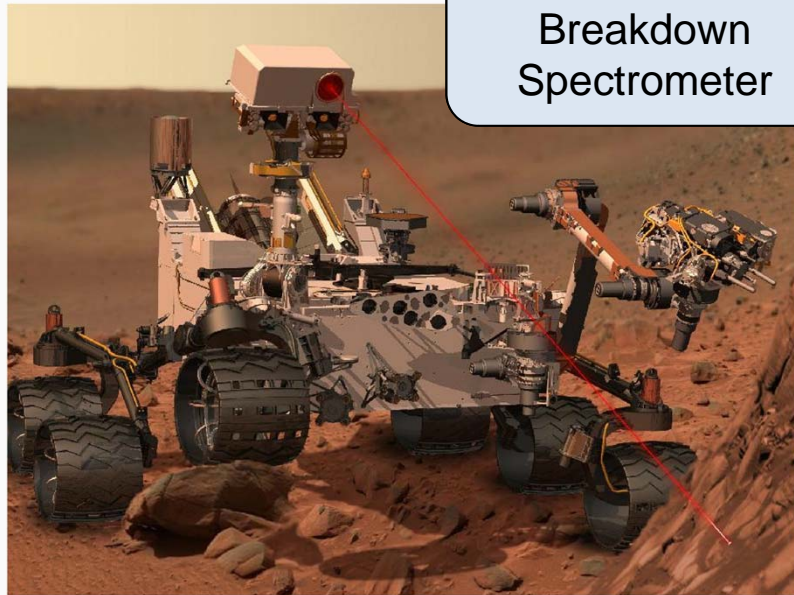
Main ingredient of the Van Allen Radiation Belts:

- Discovery of protons in the radiation belts by NASA Scout ST-2 (*Bame et al., 1962, 1963*);
- Scout: 4-stage, all solid fuel

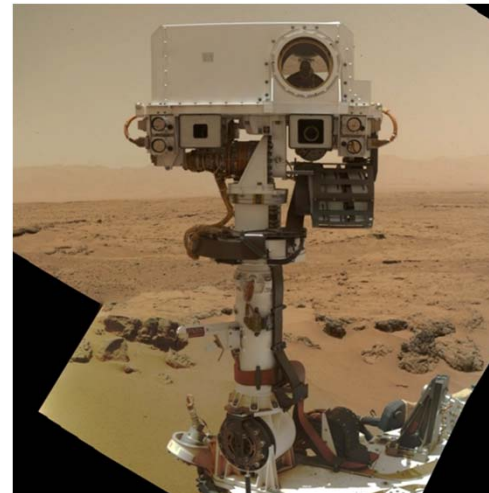


ChemCam: *Understanding the biological potential, role of water, and geological and geochemical evolution of Mars*

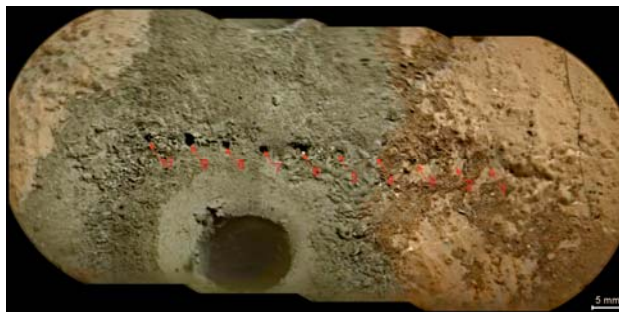
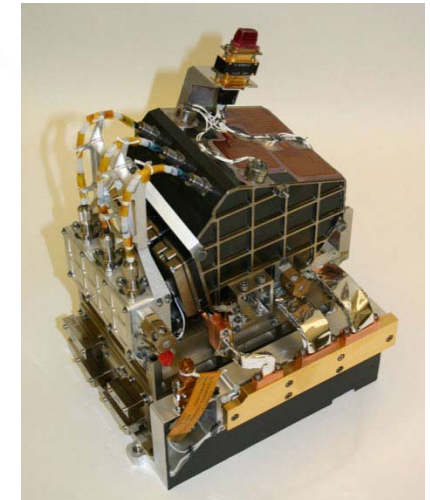
Laser-Induced
Breakdown
Spectrometer



ChemCam Mast Unit



ChemCam Body Unit



3 ChemCam spectrometers:

- Light from Mast unit split by demultiplexer
- 240-336 nm, 380-470 nm, 470-850 nm

Yellowknife Bay rock: 3.8-4.4 by old, 20% clay, neutral pH, exposed to water < 100 mya

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Mars Science Laboratory: *Understanding the biological potential, role of water, and geological and geochemical evolution of Mars*

Yellowknife Bay, Mars
Not as wet and wild as predicted!

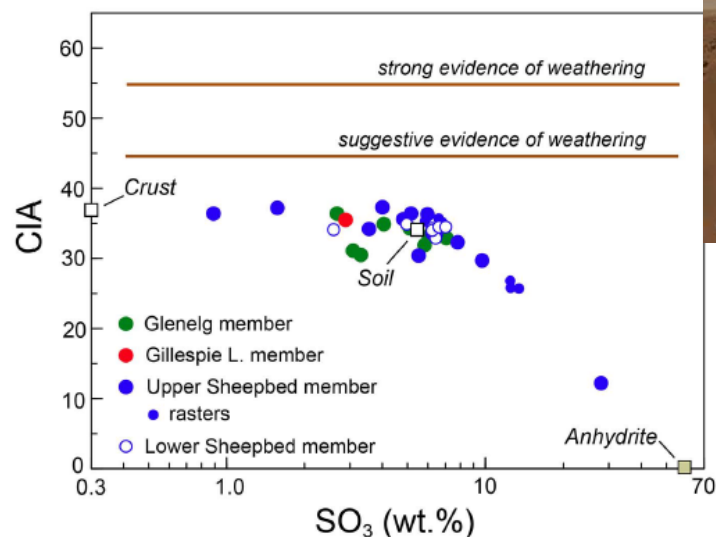
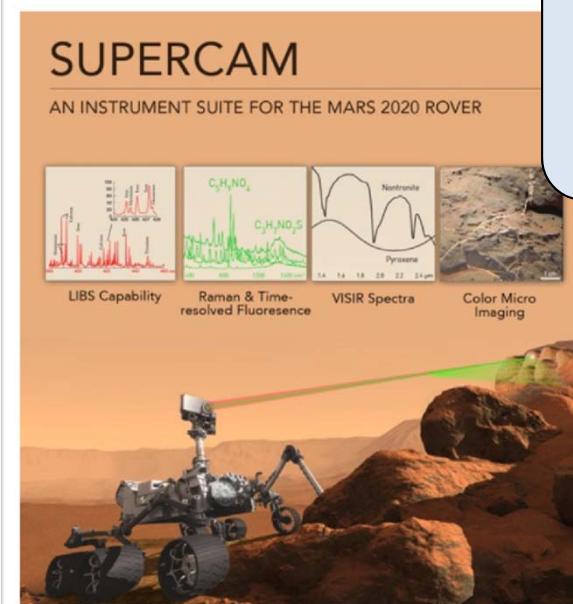


Fig. 3. Plot of CIA versus SO_3 contents for Yellowknife Bay formation APXS analyses. Shown for reference, as open squares, are average martian crust (12), local soil (64), the composition of anhydrite (CaSO_4) and horizontal lines that show the CIA values expected for basaltic sedimentary rocks that have experienced a chemical weathering history.

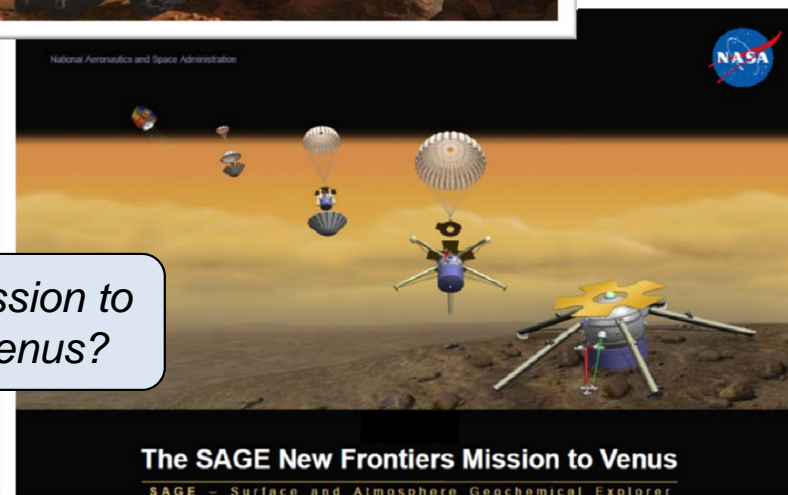
CIA = Chemical index of alteration (Ca, K, Na)

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LIBS +
Raman:
Mars
2020

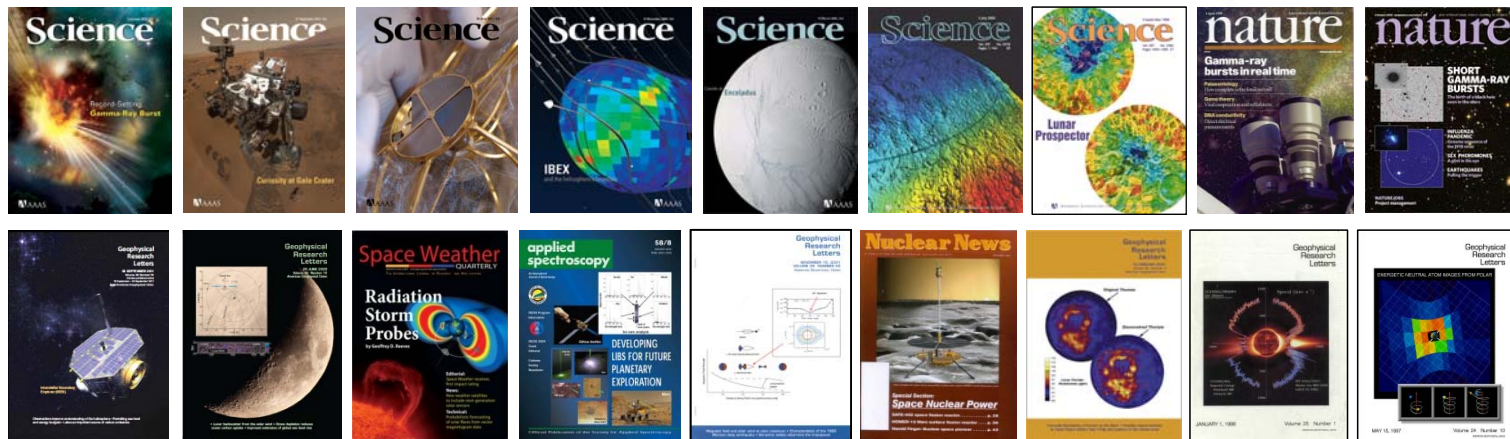
Mission to
Venus?



The SAGE New Frontiers Mission to Venus
SAGE - Surface and Atmosphere Geochemical Explorer

Los Alamos in Space: *Supporting the National Security Mission through a Rich Cycle of Innovation and Discovery*

- Signature Discovery



- Revolutionary Measurement: *a quest for the unknown, allow for the unexpected*
- Forward Deployment: *harsh environment, limited resources, autonomous operation*

Slide 18

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